

FIG. 1A

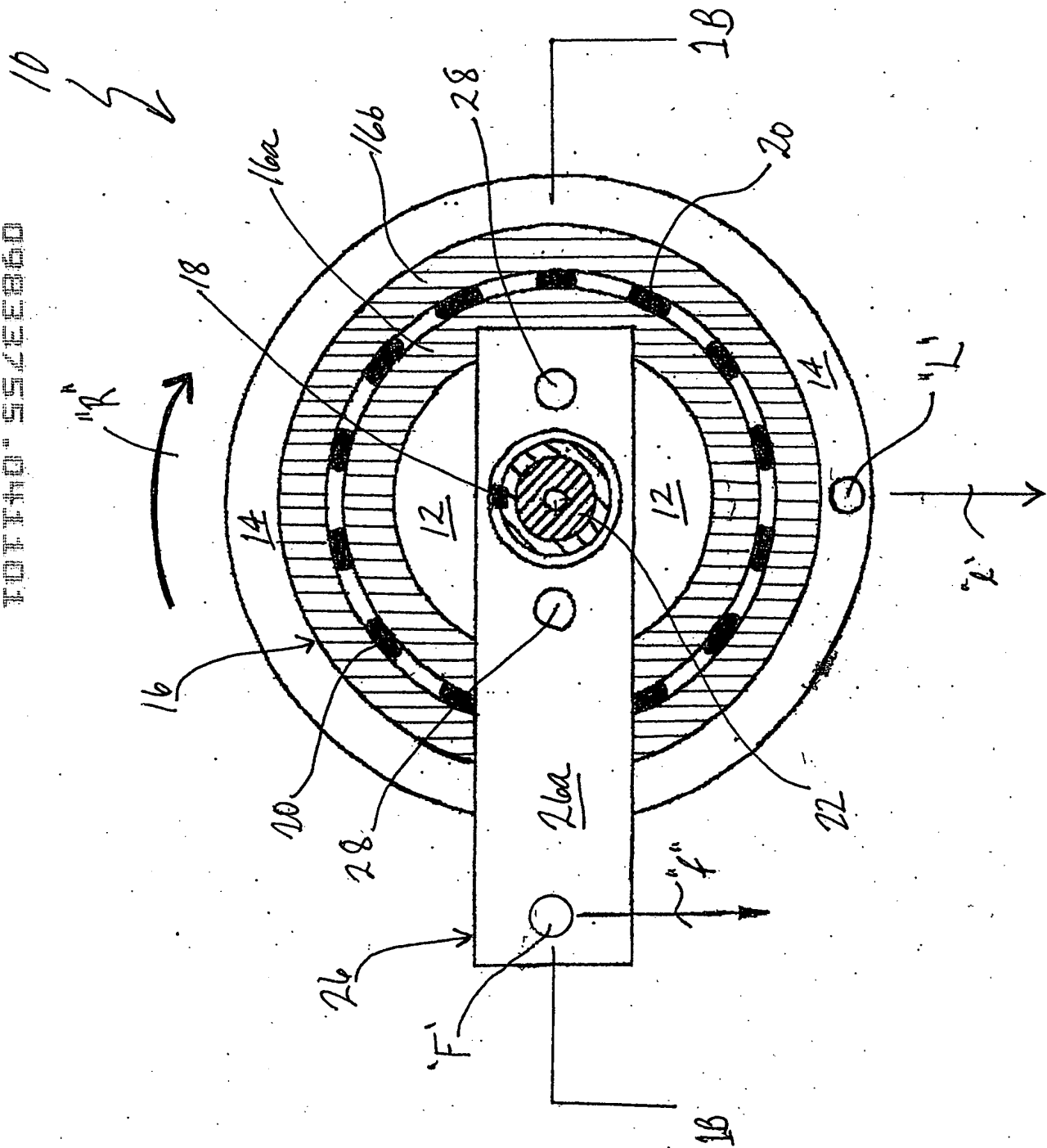


FIG. 1A

FIG. 1A

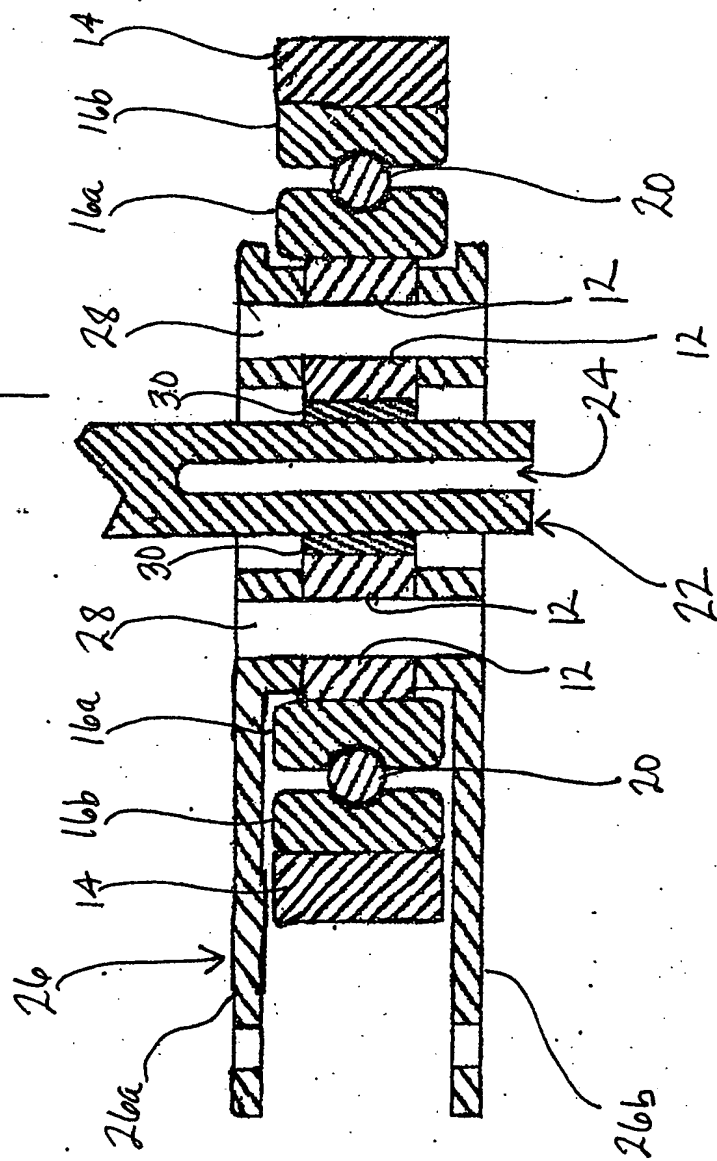


FIG. 1B

Table 1

PV Limits based on Increasing Speed and Increasing Pressure

Test #	Polymeric Matrix	Commercially Available Competitive Materials (PreBlended)	Compositions							PV Limit Based on Increasing Velocity @ 100 psi	PV Limit Based on Increasing Pressure @ 25 FPM
			Polymeric Matrix Materials used for exemplary Compositions	%	First Additive	%	Second Additive(s)	%	Method Of Blending		
1	PEI		Ultem 1010	55	DKD Fiber	30	TFE Fiber	15	Solvent	90,000	50000 +
2	PEI		Ultem 1010	55	DKD Fiber	30	TFE Fiber	15	Solvent	97,000+	65000 +
3	PEI		Ultem 1010	55	DKD Fiber	30	TFE Fiber	15	Solvent	90,000+	
4	PEI		Ultem 1010	55	DKD Fiber	30	TFE Fiber	15	Dry	60,000	
5	PEI		Ultem 1010	55	DKD Fiber	30	TFE Powder	15	Solvent	60,000	
6	PEI		Ultem 1010	50	DKD Fiber	25	BN Platelets	25	Solvent	90,000+	
7	PEI		Ultem 1010	70	TFE Fiber	30			Solvent	40,000	
8	PEI		Ultem 1010	70	DKA Fiber	30			Solvent	30,000	
9	PEI		Ultem 1010	60	DKA Fiber	40			Solvent	50,000	
10	PEI		Ultem 1010	50	DKA Fiber	50			Solvent	60,000	
11	PEI		Ultem 1010	40	DKA Fiber	60			Solvent	70,000	
12	PEI		Ultem 1010	30	DKD Fiber	60	BN Platelets	10	Solvent	90,000+	
13	PEI		Ultem 1010	100					PreBlend	< 10,000	
14	PEI	Ultem 7201		80	Carbon Fiber	20			PreBlend	40,000	
15	PEI	Ultem 7301		75	Carbon Fiber	25			PreBlend	20,000	
16	PEI	EL 4040		80			TFE Powder	20	PreBlend	20,000	
17	PEEK		Victrax 150	55	DKD Fiber	30	BN Platelets	15	Dry	60,000	
18	PEEK		Victrax 150	55	DKD Fiber	30	BN Platelets	15	Dry	50,000	
19	PEEK		Victrax 150	55	DKD Fiber	25	BN Platelets	25	Dry	80,000	
20	PEEK	Victrax FC 30		70	Carbon Fiber	10	Graphite Powder/TFE Powder	10/10	PreBlend	30,000	30,000
21	PEEK	Victrax FC 30		70	Carbon Fiber	10	Graphite Powder/TFE Powder	10/10	PreBlend	40,000	30,000
22	PEEK	Victrax CA 30		70	Carbon Fiber	30			PreBlend	30,000	30,000
23	PEEK	Victrax CA 30		70	Carbon Fiber	30			PreBlend	50,000	40,000
24	PI		Aurem	55	DKD Fiber	30	TFE Fiber	15	Dry	70,000	
25	PI/PEI		Aurem/Ultem 1010	44/11	DKD Fiber	30	TFE Fiber	15	Concentrate	90,000	
26	PI/PEI		Aurem/Ultem 1010	37.5/12.5	DKD Fiber	25	BN Platelets	25	Concentrate	90,000	
27	PI	Aurem JNF 3020		80			TFE Powder	20	PreBlend	50,000	50,000
28	PI	Aurem JNF 3025					TFE Powder		PreBlend	40,000	30,000
29	PI	Aurem JCN 6530		70	Carbon Fiber	30			PreBlend	40,000	45,000
30	PI	Aurem JCF 6525			Carbon Fiber				PreBlend	40,000	30,000
31	LCP/PEI		LCP/Ultem 1010	37.5/12.5	DKD Fiber	25	BN Platelets	25	Concentrate	90,000	
32	LCP	Vectra B230		70	Carbon Fiber	30			PreBlend	10,000	15,000
33	PPS		Ticona 020584	55	DKD Fiber	30	TFE Fiber	15	Dry	50,000	56,000
34	PPS		Ticona 020584	50	DKD Fiber	25	BN Platelets	25	Dry	50,000	
35	PPS	OL 4060		70			TFE Powder	30	PreBlend	30,000	30,000
36	PAI	Torlon 7130		70	Carbon Fiber	30			PreBlend	30,000	35,000
37	PAI	Torlon 4301		85			Graphite Powder/TFE Powder	12/3	PreBlend	30,000	20,000

Figure 2

Table 2

TOD Bearing Wear Properties

Test #	Polymeric Matrix	Commercially Available	Compositions				Method Of Blending	Wear (K)			Shaft Temperature (F)			Coefficient of Friction		
			Polymeric Matrix	Materials used for exemplary	%	First Additive	%	Second Additive(s)	%	Method Of Blending	Pressure x Velocity			Pressure x Velocity		
											100x100			100x100		
											50x200	100x100	200x50	50x200	100x100	200x50
38	PEI		Utem 1010		55	DKD Fiber	30	TFE Fiber	15	Solvent	8	12	16	140	170	180
39	PEI		Utem 1010		55	DKD Fiber	30	TFE Fiber	15	Extrusion	25	21	23	180	255	220
40	PEI		Utem 1010		55	DKD Fiber	30	TFE Powder	15	Solvent	13	15	25	200	250	195
41	PEI		Utem 1010		50	DKD Fiber	25	BN Platelets	25	Solvent	15	23	12	170	170	160
42	PEI		Utem 1040		30	DKD Fiber	60	BN Platelets	10	Solvent	18	10	12	132	170	174
43	PEI	Utem 7201			80	Carbon Fiber	20			PreBlend	173	70	79	365	265	335
44		EL4040			80			TFE Powder	20		101	52	66	250	250	250
45	PEEK		Victrax 150		55	DKD Fiber	30	TFE Fiber	15	Dry	22	26	19	320	245	250
46	PEEK		Victrax 150		55	DKD Fiber	30	BN Platelets	15	Dry	9	9	6	150	175	160
47	PEEK		Victrax 150		50	DKD Fiber	25	BN Platelets	25	Dry	6	6	2	155	175	160
48	PEEK		Victrax 150		50	DKD Fiber	25	BN Platelets	25	Extrusion	19	19	10	135	175	150
49	PEEK		Victrax 150		30	DKD Fiber	70			Dry	24		36	142		142
50	PEEK		Victrax 150/Utem 1010		41/9	DKD Fiber	25	BN Platelets	25	Concentrate	19	19	10	135	180	165
51	PEEK	Victrax FC30			70	Carbon Fiber	10	Graphite Powder/TFE Powder	10/10	PreBlend	177	160	251	306	290	260
52	PEEK	Victrax CA30			70	Carbon Fiber	30			PreBlend	500	77	120	350	310	375
53	PEEK	LL 4030			85			TFE Powder	15	PreBlend	172	22	30	204	238	208
54	PI/PEI		Aurem/Utem 1010		44/11	DKD Fiber	30	TFE Fiber	15	Concentrate	20	35	20	210	205	220
55	PI/PEI		Aurem/Utem 1010		37.5/12.5	DKD Fiber	25	BN Platelets	25	Concentrate	4	10	9	190	212	190
56		Aurem JCF 6525								PreBlend	269	240	185	374	115	337
57	PI	Aurem JCN 6530			70	Carbon Fiber	30			PreBlend	115	109	161	375	390	340
58	PI	Aurem JNF 3020			80			TFE Powder	20	PreBlend	113	108	143	250	334	150
59	LC/PEI		LCPU/Utem 1010		37.5/12.5	DKD Fiber	25	BN Platelets	25	Concentrate	3	21	1	185	176	170
60	LCP	Xydar 96043			40	Carbon Fiber	60			PreBlend	241	223	210	187	180	100
61	LCP	Vectra B230			70	Carbon Fiber	30			PreBlend	160	125	50	351	290	269
62	PPS		Ticona 020584		55	DKD Fiber	30	TFE Fiber	15	Dry			16		251	
63	PPS		Ticona 020584		50	DKD Fiber	25	BN Platelets	25	Dry	26	18	10	210	226	234
64	PPS	OL 4040			80			TFE Powder	20	PreBlend	256	48	110	298	201	251
65	PPS	1300AR15TFE15			70	Aramid Fiber	15	TFE Powder	15	PreBlend	124	192	509	250	302	272
Footnote 1: The PV Limit based on increasing speed at 200 psi is:																
			PV Limit		Shaft Temperature		Coefficient of Friction									
			180,000		315		0.02									
			180,000		310		0.03									

Figure 3

Table 3

Wear Properties at High Values of Pressure x Velocity

Test #	Polymeric Matrix	Commercially Available Competitive Materials (PreBlended)	Compositions					Wear (K)			Shaft Temperature (F)					Coefficient of Friction				
			Polymeric Matrix Materials used for exemplary Compositions	%	First Additive	%	Second Additive(s)	%	Method Of Blending	Pressure x Velocity			Pressure x Velocity			Pressure x Velocity				
										200 X 50	200 X 100	200 X 200	200 X 400	200 X 500	200 X 600	200 X 100	200 X 200	200 X 400	200 X 600	200 X 800
66	PEI		Ultem 1010	55	DKO Fiber	30	TFE Fiber	15	Solvent	16	81	70	Melted (1)		180	210	330	0.21	0.24	0.12
67	PEI		Ultem 1010	55	DKO Fiber	30	TFE Fiber	15	Extrusion	23		72	Melted (5)		220		340	0.28		Melted (1)
68	PEI		Ultem 1010	50	DKO Fiber	25	BN Platelets	25	Solvent	12		55	35	Melted (2)	160	241	220	Melted (2)		0.04
69	PEI		Ultem 1010	30	DKO Fiber	60	BN Platelets	10	Solvent	12	18	50	23	79	174	229	260	0.24	0.17	0.1
70	PEI		Ultem 1040	28	DKO Fiber	70	DC4-7105	2	Solvent	39	40	30	84	43	160	155	260	0.24	0.2	0.08
71	PEI	Ultem 7201		80	Carbon Fiber	20			PreBlend	79										
72	PEEK		Victrex 150	55	DKO Fiber	30	TFE Fiber	15	Dry	19	63	63	228	Melted (6)	250	250	290	0.3	0.2	0.1
73	PEEK		Victrex 150	50	DKO Fiber	25	BN Platelets	25	Extrusion	10		22	81	Melted	240		259	0.2		0.08
74	PEEK		Victrex 150	50	DKO Fiber	25	BN Platelets	25	Dry	2	36			33	160	193		0.2		0.06
75	PEEK		Victrex 150	29	DKO Fiber	70	CAPOW L38/H	1	Dry	22	31	16	25	19	140	170	183	0.2		0.06
76	PEEK		Victrex 150	48	DKO Fiber	25	BN Platelets/DC4-7105	25/2	Dry	12	25	22	20	15	197	200	222	0.2	0.16	0.1
77	PEEK	Victrex FC30		70	Carbon Fiber	10	Graphite Powder/TFE Powder	10/10	PreBlend	251					260	Melted		0.2	Melted	
78	PEEK	Victrex CA30		70	Carbon Fiber	30			PreBlend	120					375	Melted		0.7	Melted	
79	PPS		Ticona 020584	28	DKO Fiber	70	DC4-7105	2	Dry	16	46	32	74	Melted	200	250	245	0.28	0.3	0.12
80	PPS		Ticona 020584	30	DKO Fiber	10	Graphite Powder	60	Dry	50	46	51	Melted	390	180	295	360	0.34	0.32	0.26
81	PPS	OL 4040		80			TFE Powder	20	PreBlend	110	165									
82	P/PEI		Aurem Ultem 1010	44/6	DKO Fiber	25	TFE Fiber	25	Concentrate	20		80	Melted (5)		220		315	Melted (5)		0.14
83	P/PEI		Aurem Ultem 1010	38/12	DKO Fiber	25	BN Platelets	25	Concentrate	4	20	46	32	Melted (5)	180		235	Melted (5)		0.12
84	Pi	Aurem JCN 6530		70	Carbon Fiber	30			PreBlend	201		Melted (1)	Melted (3)		340	Melted (1)	Melted (3)	0.48	Melted (1)	Melted (3)
85	Pi	Aurem JNF 3020		80			TFE Powder	20	PreBlend	143	267				150	270		0.19	0.2	

Footnotes:

1. After 1 Hour
2. After 3 Hours
3. After 5 Minutes
4. After 15 Minutes
5. After 1 Minute

Figure 4

Table 4

Bearing Wear Properties at High Loads and Low Speeds

Test #	Polymeric Matrix	Commercially Available Competitive Materials (PreBlended)	Compositions						Wear (K)	Shaft Temperature (F)	Coefficient of Friction
			Polymeric Matrix Materials used for exemplary Compositions	%	First Additive	%	Second Additive(s)	%			
86	PEI		Ultem 1010	55	DKD Fiber	30	TFE Fiber	15	Solvent	280	0.2
87	PEI		Ultem 1010	50	DKD Fiber	25	BN Platelets	25	Solvent	160	0.32
88	PEI		Ultem 1010	30	DKD Fiber	60	BN Platelets	10	Solvent	170	0.3
89	PEI		Ultem 1040	28	DKD Fiber	70	DC4-7105	2	Solvent	143	0.13
90	PEI	Ultem 7201		80	Carbon Fiber	20			PreBlend	Melted	Melted
91	PEEK		Victrex 150	55	DKD Fiber	30	TFE Fiber	15	Dry	230	0.06
92	PEEK		Victrex 150	50	DKD Fiber	25	BN Platelets	25	Dry	180	0.09
93	PEEK		Victrex 150	29	DKD Fiber	70	CAPOW L38/H	1	Dry	210	0.1
94	PEEK		Victrex 150	48	DKD Fiber	25	BN Platelets/DC4-7105	25/2	Dry	250	0.1
95	PEEK		Victrex 150	48	DKD Fiber	25	BN Platelets/DC4-7105	25/2	Dry	180	0.16
96	PEEK	Victrex FC30		70	Carbon Fiber	10	Graphite Powder/TFE Powder	10/10	PreBlend	Melted	Melted
97	PEEK	Victrex CA30		70	Carbon Fiber	30			PreBlend	Melted	Melted
98	PPS		Ticona 020584	28	DKD Fiber	70	DC4-7105	2	Concentrate	250	0.17
99	PPS		Ticona 020584	30	DKD Fiber	10	Graphite Powder	60	Concentrate	250	0.36
100	PPS	OL 4040		80			TFE Powder	20	PreBlend	Melted	Melted

Figure 5

TABLE 5

Additive	Thermal Conductivity (W/m°C)
Aluminum Flake	204
Boron Nitride Powder	33-200
Bronze Powder	26
Graphite Powder	
Steel Fiber	52
Stainless Steel Fiber	12-22

FIGURE 6

Polymeric Matrix Material	Composition						Wear (K)	Shaft Temp (°F)	Coefficient of Friction	Test Duration (Hrs.)
	First Additive	Second Additive	% By Volume	% By Weight	Type of Carbon Fiber	Method of Blending				
PEI Ultem1040	DKD		70/30	57.5/42.5	Pitch	SOLVENT	26	175	0.34	24
PEI Ultem1040	DKD		60/40	46/54	Pitch	SOLVENT	37	163	0.22	24
PEI Ultem1040	AGM 94		70/30	62/38	PAN	SOLVENT	206	360	0.44	24
PEI Ultem1010	AGM 94		60/40	51/49	PAN	SOLVENT	366	205	0.4	26
PEI Ultem1010	AGM 94		50/50	41/59	PAN	SOLVENT	210	280	0.4	24
PEI Ultem1040	AGM 95		50/50	40/60	PITCH	SOLVENT	180	290	0.34	24
PEI Ultem 1040	AGM 94		43/57	35/65	PAN	SOLVENT	530	200	0.44	24
PEI Ultem 1010	AGM 94	BN Platelets	60/20/20	49/23/28	PAN	SOLVENT	10,000+	260	0.46	0.16
PEI Ultem 1040	VMX-24	BN Platelets	60/20/20	48/24/28	PITCH	SOLVENT	10,000+	229	0.5	1
PEI Ultem 1040	VMX-24		60/40	50/50	PITCH	SOLVENT	112	370+	0.7	21
PEEK	DIALEAD K223 HG	BN Platelets	60/40	48/52	PITCH	DRY	12	140	0.14	24
PPS	DKD		60/40	48/52	Pitch	DRY	24	225	0.3	24
PPS	DIALEAD K223 HG	BN Platelets	64/18/18	50/25/25	PITCH	DRY	6	125	0.22	24
PPS	FORTAFIL				PAN	DRY	599	253	0.36	24
PPS	DIALEAD K223 HG LF	BN Platelets			PITCH	DRY	6	180	0.36	24
PC	DKD	BN Platelets	60/20/20	47/27/27	Pitch	SOLVENT	70	141	0.16	24
PC	GM 130	BN Platelets	60/20/20	48/23/29	PAN	SOLVENT	9875	300	0.36	2
PEI Ultem 1040	DKD		87.5/12.5	80/20	Pitch	SOLVENT	57	195	0.24	24
PEI Ultem 1010	DKD		64/36	50/50	Pitch	SOLVENT	24	190	0.26	100
PEI Ultem 1010	DKD		54/46	40/60	Pitch	SOLVENT	38	176	0.34	24
PEI Ultem 1010	DKD		43/57	30/70	Pitch	SOLVENT	29	158	0.24	100
PEI Ultem 1010	DKD	BN Platelets	43/49/8	30/60/10	Pitch	SOLVENT	12	174	0.24	100
PEI Ultem 1010	DKD	BN Platelets	64/18/18	50/25/25	Pitch	SOLVENT	12	160	0.18	100

FIGURE 7

Table 7

T07T40" 55ZEE960

Product Name	Supplier	Type of Fiber	Tc (W/mC)	Density (gm/cc)	Average Diameter (microns)	Average Length (microns)	Aspect Ratio
DKA	BPAmoco Corporation	Pitch	900	2.2	10	200	
DKD	BPAmoco Corporation	Pitch	600	2.2	10	200	
VMX-24	BPAmoco Corporation	Pitch	22	1.9	11	200	
AGM 94	Asbury Graphite Mills	PAN		1.81	7	150	
AGM 95	Asbury Graphite Mills	Pitch		1.91	11	200	
Fortafil 382	Fortafil Fibers Inc.	PAN		1.8	7	175	
Fortafil 482	Fortafil Fibers Inc.	PAN		1.8	7	175	
Grafil GM130E	Graphil Inc.	PAN	7	1.8	7	130	
Pyrofil TR50S	Graphil Inc.	PAN	7	1.82	7	8000	
Dialead K 6371M	Mitsubishi Chemical America	Pitch	140	2.1	7	50	
Dialead K 223HG LG	Mitsubishi Chemical America	Pitch	540	2.2	7	6000	
Dialead K 223HG	Mitsubishi Chemical America	Pitch	540	2.2	7	300	

Figure 8

Table 8

T0TTH0"SS4EEB60

Test #	Polymeric Matrix	Comparative Compositions						Wear Properties			
		Polymeric Matrix Materials used for Comparative Compositions		First Additive	%	Second Additive(s)	%	Wear (K)	Shaft Temperature (F)	Coefficient of Friction	Test Duration (hrs)
			%								
101	PEI	Ultem 1010		Aluminum flake				4400	150	<0.7	0.03
102	PPS		65	Aluminum flake	16	BN Platelets	19	<10000	170	0.48	1
103	PEI	Ultem 1010	60	Bronze Powder	40			935	240	0.45	24
104	PEI	Ultem 1040	60	Bronze Powder	20	Graphite Flake	20	225	215	0.42	24
105	PEI	Ultem 1040	60	Steel Fiber	20	BN Platelets	20	969	245	0.5	18
106	PC		81	Stainless Steel Fiber	19			657	241	0.54	10.5
107	PEI	Ultem 1010	60			BN Platelets	40	10,324	240	0.46	0.31
108	PEI	Ultem 1010	64	AGM 3243 Graphite	36			167	190	0.34	40

Figure 9

TABLE 9

Matrix	% Wgt.	Fiber	% Wgt.	Filler	% Wgt.	In-plane	Thru-plane	IN-plane
XYDAR 96403 LCP	40	DKD	60			2.85	5.13	
XYDAR 96403 LCP (Reprocessed)	40	DKD	60			2.94	6.83	
PPS	40			Aluminum Flake	60	8.58	8.13	
PPS	30			Aluminum Flake	70	14.98	15.12	
PPS	20			Aluminum Flake	80	20	21.7	
PPS	40	DKD	30	Aluminum Flake	30	4.5	5.36	
PPS	50	DKD	50			2.52	4.65	
PPS	40	DKD	60			2.92	7.36	
PPS	30	DKD	70			5.38	9.5	
PPS	50			Boron Nitride	50	0.8	1.1	
PEI	55	DKD	25	Teflon Flock	25	0.99	1.6	
PEEK	50	DKD	25	Boron Nitride	25	1.15	2.86	
PPS	50			Aluminum Flake	50	1.76	2	
PEEK	30	DKD	70			4.39	10.5	
PEEK	50			Boron Nitride	50	1.69	2.1	
PPS	50			Aluminum Flake Boron Nitride	25/25			4.79
XYDAR 96403 LCP	40	DKD	60					1.97
PEI	50	DKA	50					1.44
PEI	50	DKD	25	Boron Nitride	25			1.56
FERRO 511TG 72001 PEN	40	BN PWD	60					3.82
PEI	70	DKA	30					0.82
PEI	60	DKA	40					1.03
PEI	40	DKA	60					2.51

FIGURE 10

FOI b7D 55222860